Final Project Description Report

For Contract No.
DACA42-03-C-0040

Title:
Proton Exchange Membrane (PEM) Fuel Cell Demonstration Of Domestically Produced PEM Fuel Cells in Military Facilities

Submitted To:
US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory
Broad Agency Announcement CERL-BAA-FY02

Submitted by:
DTE Energy Technologies, Inc.
37849 Interchange Drive
Farmington Hills, MI 48335

For Project Located At:
Selfridge Air National Guard Base, Michigan

March 5, 2005

Executive Summary

DTE Energy Technologies (Contractor) and Plug Power Inc. (Manufacturer) installed, monitored and maintained two (2) CHP Fuel Cell Systems at the Selfridge Air National Guard Base, Michigan (Site Host) for a period of fourteen months (Operating Period).

The objective of this project (Project) was to plan, install, and operate CHP Systems in a military base environment, generating electricity and heat to support base facilities. The facility has been selected to best demonstrate CHP system use in military facilities in a configuration that offered technology transfer and demonstrated reliability to similar facilities at other Department of Defense facilities. Analysis of energy savings was not a stated objective of this project.

Installation and commissioning of systems were completed on November 26, 2003. The systems were located at the New Base Fire Station, Building 859. The new base Fire, Crash, and Rescue station at 28000 George Avenue is a large facility that provides Crash and Rescue capability for the Base and Airfield in the surrounding Macomb County Area. The mechanical systems at this facility are of an industrial nature.

Contractor has provided the site planning, preparation and installation of CHP Systems. The Manufacturer is responsible for CHP System manufacture, delivery, and technical support to the Contractor.

The 5kW CHP Systems, manufactured by Plug Power Inc., incorporate combined heat and power capability to provide electricity, and allow recovered waste heat from the CHP Systems to provide heat for heating or domestic hot water. The system operates using natural gas as a fuel and in grid parallel mode to provide supplemental on-site power and usable heat to specific facilities. Additionally, the CHP Systems incorporate standby capability to allow the units to supply power to segregated critical loads during periods of electric utility grid (Grid) outage.

The point of contact at Selfridge ANG is Mr. Michael Anderson who can be contacted at (586) 307-5402.

Table of Contents

Update Table of Contents

Deleted: 3
Deleted: 4
Deleted: 3
Deleted: 4
Deleted: 3
Deleted: 4
Deleted: 3
Deleted: 5
Deleted: 3
Deleted: 5
Deleted: 3
Deleted: 5
Deleted: 3
Deleted: 6
Deleted: 3
Deleted: 6
Deleted: 3
Deleted: 7
Deleted: 3
Deleted: 7
Deleted: 3
Deleted: 7
Deleted: 3
Deleted: 8
Deleted: 3
Deleted: 8
Deleted: 3
Deleted: 8
Deleted: 3
Deleted: 10
Deleted: 3
Deleted: 10
Deleted: 3
Deleted: 10

Proposal – Proton Exchange Membrane (PEM) Fuel Cell Demonstration of Domestically Produced Residential PEM Fuel Cells in Military Facilities

1.0 Descriptive Title

Combined Heat and Power Fuel Cell System (CHP System) Demonstration at Selfridge Air National Guard Base, Michigan (East North Central Region)

2.0 Name, Address and Related Company Information

DTE Energy Technologies (Contractor)
37849 Interchange Drive
Farmington Hills, Michigan 48335

Data Universal Numbering System (DUNS) Number: 111996430
Commercial and Government Entity (CAGE) Code: 1UM49
Taxpayer Identification Number (TIN): 383394820

DTE Energy Technologies, a wholly owned subsidiary of DTE Energy, whose primary business focus is establishing a leadership position in the emerging distributed generation industry. Contractor is uniquely positioned to offer one-stop sales, engineering, and service to energy customers using a best of breed portfolio of new technology products and control services.

3.0 Production Capability of the Manufacturer

CHP Systems are manufactured at Plug Power's Latham, New York manufacturing facility. This facility, which opened in February 2000, is comprised of 50,000 square feet of dedicated production and production test facilities. Manufacturer employs approximately 100 personnel in its production areas. The production processes are designed around the principles of Lean Manufacturing, and use the Toyota Production System as a model. As such, planning and production is via a "pull system" that is, systems are produced only as orders pull demand for product through the production system. Lead-time for delivery is between eight (8) and twelve (12) weeks for large orders, smaller orders (less than ten) can be fulfilled immediately. Current production capability allows for the manufacture of approximately five (5) units per week with the ability to significantly increase this rate.

Manufacturer agrees to provide a minimum of two (2) CHP Systems to support this Program and to provide warranty and technical support to Contractor to support the operation of the CHP Systems as specified in this proposal.

Plug Power contact information:
Mr. Scott Wilshire
Director, Marketing Engagement
968 Albany Shaker Road
Lathum, NY 12110

Tele: 518.782.7700 ext. 1338
Email: scott_wilshire@plugpower.com

4.0 Principal Investigator(s)

Gerald Nicholas
VP Customer Support
DTE Energy Technologies, Inc.

Tele: 248-427-2315
Fax: 248-427-2265
Email: Nicholasg@dteenergy.com

5.0 Authorized Negotiator(s)

Gerald Nicholas
VP Customer Support
DTE Energy Technologies, Inc.

Tele: 248-427-2315
Fax: 248-427-2265
Email: Nicholasg@dteenergy.com

6.0 Past Relevant Performance Information

DTE Energy Technologies (Contractor)

Detroit Metropolitan Wayne County Airport
Romulus, Michigan 48242
POC: Mr. Robert Murphy, (734) 942-3556
Project Title: Midfield Terminal 17MW Co-generation Project
Contract Identification Number: N/A

- Contract Completion Date: February, 2002
- Contract Amount: $17M

Ann Arbor News
340 E. Huron Street
Ann Arbor, Michigan 48106
POC: Mr. David Sharp, (734) 994-6804
Project Title: 2MW Standby Generation
Contract Identification Number: N/A

- Contract Completion Date: November, 2001
- Contract Amount: $1.5M

Michigan Public Services Commission
Commission Operations Division
6545 Mercantile Way
Lansing, MI 48909
POC: Dr. Nicholas Nwabueze, 517.241.6137
Project Title: Michigan Energy Efficiency Grant PSC-03-02
Contract Identification Number: PSC-03-02

- Contract Completion Date: September, 2003
- Contract Amount: $395,000

Plug Power Inc. (Manufacturer)

Long Island Power Authority
333 Earle Ovington Blvd
Suite 403
Uniondale, NY 11553
POC: Mr. Daniel Zaweski, (516) 719-9886
Project Title: Fuel Cell Demonstration Program
Contract Identification Number: N/A

- Contract Award Date: May 15, 2001
- Contract Amount: $7M
- Contract Award Date: February 22, 2002
- Contract Amount: $3.6M

New York State Energy Research and Development Authority
17 Columbia Circle
Albany, NY 12203-6399
POC: Mr. James Foster, (518) 862-1090 x3376
Project Title: Fuel Cell Demonstration Project
Contract Identification Number: No. 4870 - ERTER - BA - 99

- Contract Award Date: January 25, 1999
- Contract Amount: $3M

National Fuel Gas Corporation
10 Lafayette Square
Buffalo, NY 14203
POC: Mr. Rob Eck, (716) 857-7711
Project Title: Residential Fuel Cell Demonstration Project
Contract Identification Number: N/A

- Contract Award Date: February, 2002
- Contract Amount: $200K

7.0 Host Facility Information

Selfridge Air National Guard Base is a joint military community located 22 miles east of Warren, Michigan, on Lake St. Claire. As the last base in Michigan, Selfridge supports a population of 50,000 people. Selfridge Air National Guard Base is defined as the Site Host Facility. The base is home to both U.S. Air Force and U.S. Army garrisons. The electricity provider for Selfridge is Detroit Edison, natural gas is provided by CMS Energy.

Appendix 1 of the Initial Report contains pictures of the facility's main gate.

8.0 Fuel Cell Installation

The contractor along with the Air Force Site Host Facility personnel identified the new Fire and Rescue Building 859 the location for this project. Fuel Cell #1 and Fuel Cell #2 were located outdoors and adjacent to the existing standby generator. This location is electrically and mechanically close to all the utilities needed for the installation. The Fire and Rescue building is 8000 square feet and carries approximately 24kW of load which calculates to approximately 17,280kWH/month. The two units were commissioned on November 26, 2003 and produced 4kW each for a total of 8kW, which calculates to approximately 5,760kWH/month. The units were base loaded and were 25% electrically efficient and 55% efficient with full CHP heat recovery. The operating procedure is as follows; the units are pre-programmed to run at 4kW each into the building, for a total base load of 8kW. Monitoring was done via telephone modem and was communicated to the DTE Energy Technologies SOC center in Farmington Hills Michigan. Fuel cell operating procedure in relation to the existing diesel standby is as follows. Upon the loss of utility the Auto Transfer Switch (ATS) starts the diesel standby generator and also toggles a relay which takes the fuel cells offline. After the diesel standby is up and running, the ATS switches the building load onto the generator. The fuel cell remains offline until two events take place. #1 – utility returns and ATS returns to normal. #2 – Air Force Site Host Facility personnel reset the lockout relay manually (pushbutton) in the mechanical room.

9.0 Electrical System

The two fuel cells had independent feeder cable to an existing electrical panel in the Fire and Rescue mechanical room. These feeders were single phase 120VAC 50A rated. Each fuel cell had a 50A molded case circuit breaker installed in an existing electrical panel in the Fire and Rescue mechanical room. The connected power output was 10kW and provided a portion of the base load for the Fire and Rescue building. The fuel cells are grid dependent and continuously provided electrical power. If utility connection was lost the fuel cells went offline.

10.0 Thermal Recovery System

The fuel cells' thermal output was connected to a common header, which then traveled into the Fire and Rescue mechanical room. This thermal loop was constructed of 1" copper tubing and had an independent pump to circulate the glycol/water mixture. The loop was connected to a plate and frame heat exchanger rated at 56Mbtu/Hr at 130 degrees F. This heat exchanger was in the return loop of the existing boilers and was load balanced via a manual valve. This Plate and Frame heat exchanger was used to preheat the water entering the boilers. The existing return loop temperature is 160 degrees F with a 20 degree ΔT. The thermal output of the two fuel cells operating at 4kW each for a total of 8kW was 42Mbtu/Hr. The thermal output was continuous to supplement the existing heating system. The system also included solenoids and an aqua stat to stop the circulation of the thermal recovery system in the event the building's system reaches a temperature such that thermal recovery is not required.

11.0 Data Acquisition System

Two systems acquired data from the fuel cell. The first was an on board Mitsubishi processor that was in the System and Reformer Controller (SARC). This continually monitored the unit for E-stop and over 100 different conditions as well as any abnormalities. E- Stop condition would exist for the following conditions: Cabinet flow switch FS1, cathode air flow falls low, high gas pressure, gas leaks methane FG1 and hydrogen HS1 , cooling loss to electronic controls PRES2, loss of communication of the SARC and inverter, various system and high cabinet temperatures and humidifier overpressure. If any of these conditions or any other anomalies existed the unit would immediately shut down. Upon shutdown, 15 minutes of data is stored and sent to Plug Power for analysis via the on board modem. An E-mail is then generated and sent from Plug Power to the authorized service personnel.

The second data acquisition was the System Operation Center (SOC). SOC remotely monitored and controlled distributed assets via the internet, public switch networks and private circuits. There were 3 levels of SOC operation available: asset monitoring only, monitoring / dispatching and, monitoring / dispatching / energy trading. SOC hardware is Commercial off the Shelf (COTS) with the software using Extensible Mark-up Language (XML) Remote Procedure Call (RPC). In this particular application SOC monitors the fuel cell grid voltage, current, frequency and kilowatts along with the following; error codes, battery amps, battery voltage, battery temperature and system state. Data could be viewed from the internet and was monitored daily by a SOC operator. SOC would send a text message or e-mail or a phone call if the unit shut down.

12.0 Fuel Supply System

The fuel system for the two fuel cells consisted of connecting to the existing gas service for the Fire and Rescue building. The two fuel cells consumed approximately 210 CFH at full load.

13.0 Program costs

	Estimated Program Costs	Actual Program Costs
Direct Material		
Fuel Cells	$110,000	
Misc Equip	6,000	
Transaction Costs	5,000	
Total direct material	121,000	141,119
Installation and Interconnection		
Engineering	8,728	
Installation	77,643	
Equipment monitoring	5,000	
Equipment removal	4,000	
Sub-total Installation and Interconnection	95,371	85,853
Total Direct Material, Installation and Interconnection	216,371	226,972
Service, Maintenance Parts	60,000	
and Project Operation	47,300	68,217
Site Restoration	5,500	6,600
Project Total	329,171	301,789

14.0 Milestones/Improvements

System SUO1BOOOOO194 had an overall availability of 75% from November 26, 2003 to January 22, 2005. Within this time period the unit ran a total of 7,527 hours producing 24,017 kilowatt hours. System SUO1BOOOOO194 had an overall availability of 78% from November 2003 to

January 22 2005. Within this time period the unit ran a total of 7,809 hours producing 25,909 kilowatt hours.

There are a number of factors that affected the availability that can be addressed in order to improve availability at future fuel cell installations:

Issue:
Water quality concerns. Hard water from the local water source caused the system water dionization system to fail.

Improvement:
A water analysis needs to be performed at each specific site and supplied to Engineering to specifically determine appropriate water treatment methods and establish variable filter flushing and replacements schedules.

Issue:
Product could not protect itself against low temperature environment. When the units went down for various reasons the failure was exacerbated by the freezing of pumps and other components. This occurred in a matter of several hours during very cold temperatures. This freezing in turn required extensive thawing procedures to get the water systems functioning again. All of this caused delays in the troubleshooting and repair of the original cause of the fuel cell failure. Often the thawing process could take many hours and cause repairs to be delayed until the next day.
Improvement:
Work with fuel cell package engineers to assure heaters or other improvements are integrated into the product for cold weather applications.

Issue:
Due to high internal personnel turnover, all departments did not understand complete contract deliverables and in particular the 90% availability requirement.
Improvement:
Conduct regular project communications with all stake holders to assure the highest availability possible.

Issue:
The responses to repairs were scheduled on 9-5 basis with no weekend or other overtime work.
Improvement:
To meet 90% availability all emergency repairs should have been dispatched the same day as the unit failure.

Issue:
Parts delivery were standard ship (1-2) days. At times waited for parts delivery verification and then rescheduled with service for the part installation.
Improvement:
Spare parts for scheduled repair service should have been on the site for technician to use during his first visit of troubleshooting.

Issue:
Fault code diagnostics and trouble shooting took too long in many cases. Some questions needed addressing by the Engineering department of the fuel cell supplier. These were usually submitted within the fuel cell supplier organization by e-mail which seemed to delay the response time. Multiple troubleshooting trips were required by the fuel cell supplier personnel for some service problems

Improvement:
The analysis of fault codes needs to be raised to a higher level of analytical skill within the fuel cell supplier organization in a more timely fashion. Higher levels of troubleshooting skills should have been employed sooner in the diagnostic process. In addition on site, first responding service technicians need more training in reading and acting on the information from fault codes of the on board computer system. This second proposed improvement will be more cost effective once more fuel cells are operating in the field.

15.0 Decommissioning/Removal/Site Restoration

The fuel cells have been removed and sent back to Plug Power for analysis. Per the request of Selfridge Air National Guard Base the concrete pads that were used under the fuel cells are being left in place. All conduits and piping, including electrical and mechanical systems, have been removed back to the source connection point. All penetrations and anchor points have been repaired. We believe all of this work has been completed to the satisfaction of the Base personnel.

16.0 Conclusions/Summary

D|tech made reasonable efforts to meet the minimum 90% availability requirement but several obstacles prevented us from meeting the requirement of the Army, D|tech and Plug Power. A great deal of learning occurred during the demonstration project for all parties involved and these experiences should lead to the commercial implementation of new technologies such as the PEM fuel cells

The overall performance of the units was affected by certain controllable and uncontrollable variables. These variables included but are not limited to: environmental factors, parts, and service. Environmental factors included water quality and ambient temperatures. Freezing temperatures and local water quality had an adverse affect on equipment operation and repair time. Specifically there were repeated and unexpected freezing events that prevented water from flowing to the fuel cells. Local water quality was repeatedly a source of unit downtime. The improved speed of diagnostics when attempting repair is essential. This will come with experience by all parties. On-site and on-truck parts availability also have the potential to improve service response time.

Cost of the project:
Total cost of the project was $301,789. 47% of the cost was equipment, 31% of the cost was fuel cell installation and removal and 23% of the cost was operation, maintenance and service parts.

During the fourteen months that we operated the fuel cells (2 months more than planned) we made reasonable efforts to reach the 90% availability objective. The average availability for the best of the twelve months was 84%, 6% less than expected. D|tech extended a credit on the Operation Expense previously billed proportional to the availability shortfall over the average best twelve months of operation. This arrangement was accepted by the Department Of The Army.

Appendix

1) Monthly Performance statistics
2) Maintenance Logs